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## **Textile teacher students' collaborative design processes in a design studio setting**

### **Abstract**

*The purpose of the present article was to analyse textile teacher students' collaborative designing of a functional 3D textile puzzle for visually impaired children. The data collection took place across three sessions of collaborative designing: defining design constraints, visualisation and building a mock-up. Twelve first-year university-level students training to become textile teachers participated in the study, and they worked in four teams with three students in each team. We were interested in the nature of their design process and how kernel design ideas were created and transformed during the collaborative design process. The analysis focused on the teams' design activities and content logs of the video data. The video-recorded data were segmented in 2-minute intervals using INTERACT video analysis program. Each segments were classified according to 7 observable design activities. This provided a macro level analysis for all design activities during each design session and data for further analysis of different orientations of teams. The results indicated that all teams engaged in progressive design processes and were able to create unique and practical design solutions. The design processes turned out to be a problem driven in nature for two teams whereas the others engaged in a solution-driven design process.*

**Keywords:** collaborative design, design activity, design education, design problem, design process

### **Introduction**

Research on students' design process helps educators understand how to develop their pedagogies and educational methods for teaching the design process. Teaching creative practices in the art, craft and design disciplines is generally based on a studio model that usually emphasises problem-based learning (sometimes labelled as project-based learning); students are initiated into the process to

solve open-ended design projects that include certain external design constraints and that take several weeks to conduct (Lee 2009; Sawyer 2012; also Chamorro-Koc, Scott and Coombs 2014). In design education, these projects become progressively more complicated over the whole course of education, preparing students for professional practice and adaptive expertise. One of the most fundamental aspects of studio model learning is that the students are able to externally present their ideas in a form of various visible artefacts so that these ideas can be discussed and reflected. Thus, it is important that students develop confidence in their own ideas and ability to communicate about them (Cusens and Byrd 2013). Students should be taught how to express design ideas and how to transform their mental images into physical representations, so that their ideas can be discussed and reflected. Unlocking the fear of drawing is a key component to cultivate students' capability to express their design ideas (Cross 2001).

Our previous studies have indicated that textile teacher students (here, *persons studying and training to become textile teachers*) have ambivalent relations to the design process and the use of sketching as a medium for expressing design concept and developing design ideas (Laamanen and Seitamaa-Hakkarainen 2014). Rather than being educated to become designers, they are supposed to learn to teach designing and craft making to the pupils and adults. Drawing and sketching may not be as easy for textile teacher students as it is for professional designers (cf. Menezes and Lawson 2006). Nevertheless, it is important to gain experience with various tools and mediums of design ideation. Further, textile teacher students need to have experiences of design processes and collaborative learning that enables them to focus on the design constraints and collaborative ideation. In a design studio, these activities are organized upon replication of professional design task, i.e., through the use of a design brief that presents real-world design tasks. These tasks prompt students to experience the complexity of the design process: defining the design constraints, exploring and sketching design ideas, and experimenting with various materials. This article presents findings from an exploratory study aimed at investigating the collaborative design process of first-year university-level students in training to become textile teachers. The overall aim of this article is to discuss the pedagogical implications of the problem-based learning setting to facilitate collaborative design thinking. Our purpose was to analyse students' collaborative designing of a given design assignment and examine how and when the kernel design ideas were found and how these ideas were transformed toward material mock-ups during the team work. Toward that end, we organized the collaborative design setting that required textile teacher students to design a functional 3D textile puzzle for visually impaired children.

## **Collaborative designing**

The complexity of the design process emerges from its cyclical and iterative nature, and thus, the possible design solutions arise from a complex interaction between parallel refinement of the design challenge and the design ideas (Lawson 2006). Design ideas emerge gradually as a process of analysing the problem, defining the constraints of designing, proposing, testing and evaluating the design ideas and the emerging solutions (Goel 1995). In the other words, designing is seen to move back and forth between a *problem space* and a *solution space* (Dorst and Cross 2001; Goel 1995). However, it is typical for a designer to employ either a problem-driven or a solution-driven design strategy (Kruger and Cross 2006). The problem-driven designer focuses on understanding and defining the given problem and formulating the design problem in functional terms (that is, specific functions that the artefact needs to fulfil), which may leave little room for multiple solution alternatives. The solution-driven designer focuses more on generating solutions than on defining the problem, and the design problem may be reframed to suit an emerging solution. Furthermore, Sagun and Demirkan (2009) found that in a collaborative design studio setting, collaboration was focused more on the solution space than on the problem space.

A common belief is that generating several ideas might provide the chances of finding better ideas (Shah, Smith and Vargas-Hernandez 2003). However, the problem space and solution space strategies may not necessary be related to the quality of overall solution (Kruger and Cross 2006) and collaborative design thinking might require both strategies. Further, collaboration appears to have a particularly important role during generation and articulation of the design ideas; the team considers a wide range of potential solutions through an iterative and expansive process (Cross and Cross 1995). In collaborative settings, idea exchange may both facilitate and hinder idea generation, which is partially dependent on the quality of a teams' interaction (i.e., participants' motivation, social roles and relationship etc.).

Collaborative designing means a process of actively communicating and working together in identifying design constraints, creating and sharing design ideas, deliberately making joint decisions, constructing and modifying developed design solutions, and producing shared design objects, as well as evaluating their outcomes through discourse (Hennessy and Murphy 1999; Lahti, Seitamaa-Hakkarainen and Hakkarainen 2004). Further, in order to successfully address a design problem, a team must simultaneously deal with the design task itself and organize their process (Chiu 2002; Cross and Cross 1995; Lahti, Seitamaa-Hakkarainen and Hakkarainen 2004; Stempfle

and Badke-Schaub 2002). In collaborative designing, team members need to participate equally, however, the team members can have various roles and relationships during the design process (Cross and Cross 1995). Appropriate social settings (i.e., supportive atmosphere and relationships, applicable structure, positive social norms, and participants' engagement) facilitate participation for sharing ideas, organizing design process, and support the emergence of a commitment to a common goal (Chiu 2002). Besides social interaction, the availability of different materials and representations is necessary for collaboration (Binder et al. 2011).

Designing is from the very beginning focused on creating and developing design ideas that are given a material form (Ramduny-Ellis et al. 2010). Designers make sketches not just to record an idea, but to help generate it; sketches are central to the emergence of new thoughts (Menezes and Lawson 2006). Therefore, ideation with visualisation of design ideas plays the crucial role and it is critical aspect in collaborative designing: the proposed and externalized design ideas might provide external stimuli for emergence of new ideas of the team and these visible ideas can become objects of shared discussion and evaluation. Visualisation is not only drawing on the paper, the term covers the use of many various forms of representations (e.g., mind maps, material collages, mock-ups and prototype models). An important aspect of collaborative designing is working with shared design objects such as visual representations, models and concrete materials.

The participant's constructive influence in team design work is due to the way she or he interacts with the others and articulates shared design ideas (Dong 2005). During collaborative designing, the shared design ideas need to be negotiated, elaborated, accepted or abandoned. An initial design idea may work as a key or anchor idea in the design process (see Lawson 2006). However, in the real design situation, it is difficult to say which one of the shared ideas will be the kernel idea. Afterwards, it may be possible to trace the birth of the kernel design ideas by way of recorded data.

## **Method**

### **Participants and the setting of the study**

The design assignment was a part of a 10-week course called *Basics of Craft and Design Studies*. The course was a compulsory first-year course in a program for Textile Teacher Education, at University of Helsinki, Finland. The aim of the course was learn to collaborate and carry out an design project. At the time of the study, autumn 2013, the design assignment was to design a functional 3D textile puzzle for visually impaired children. Later, during the *Sewing Technology* course, the teams produced their textile puzzles and these puzzles were donated to CELIA that is

library for the visually impaired people and those with other print disabilities. Twelve voluntary participants were selected for the study among 36 course participants. The students neither knew each other very well nor had collaborated previously with each other. The students met each other during the weekly lectures followed by face-to-face teamwork sessions. The 3D textile puzzle design assignment comprised three sessions. There was one week between sessions 1 and 2, but a longer period of four weeks between sessions 2 and 3. The design assignment and organization for the each session were carefully planned. The task instructions in each design session are presented in the Table 1.

Table 1: The task instructions in each design session.

Session 1: Defining design constraints	<p><b>10 Questions:</b> Write a list of 10 questions about how to design functional 3D textile puzzle for visually impaired children</p> <p><b>Mind map:</b> Make a common mind map based on the design constraints.</p>
Session 2: Visualisation	<p><b>1. Phase: Creative problem solving task, individual work.</b></p> <ol style="list-style-type: none"> <li>1. Pick three random numbers from 1 to 15 and write them down.</li> <li>2. Pick one number from 1 to 8, and write it down.</li> <li>3. Create an interesting, potentially useful object by combining the shapes (see picture below) corresponding the numbers you picked in (1). You may combine the shapes as you like, and resize them. You may not change the shapes, other than shapes 6 and 7, which you may bend or stretch.</li> </ol> <p><b>2. Phase: Visualisation, teamwork.</b></p> <ol style="list-style-type: none"> <li>1. Share your work from previous phase and discuss your solutions.</li> <li>2. Select a theme and shapes you want to use in your team's 3D-puzzle. You may use all the shapes you picked in previous phase, and you may combine the shapes as you like.</li> <li>3. Sketch a 3D-puzzle using the shapes from (2).</li> </ol>
Session 3: Building mock-up	<p><b>Build mock-up:</b> Build up together a 3-dimensional mock-up of your puzzle using materials that your team have received. Materials are:</p> <ul style="list-style-type: none"> <li>wire and fibre fabric</li> <li>modelling clay</li> <li>thin cardboard and masking tape</li> </ul>

Note: Before collaborative designing, each student, individually, made one classical creative problem-solving task (adapted from Sawyer 2013: 33) lasting about 15 minutes. All other tasks were collaborative in nature. The variety of the given shapes (e.g., cone, cube, rectangle etc.) and themes is presented in Appendix.

During the design sessions, the teams worked in different rooms. All materials produced during the sessions (i.e., written notes, mind maps, sketches, mock-ups) were collected. The data corpus consisted of 2 x 12.5 hours of video recordings, 38 documents of written notes or sketches, and 4 mock-ups. The teams are labelled according the name of the textile puzzle they produced: Team Truck, Team Ball, Team Landscape and Team Robot. The participants' names have been anonymized in the transcript fragments. All sessions were video recorded with two stationary cameras that provided differing but relevant views (see Figure 1).

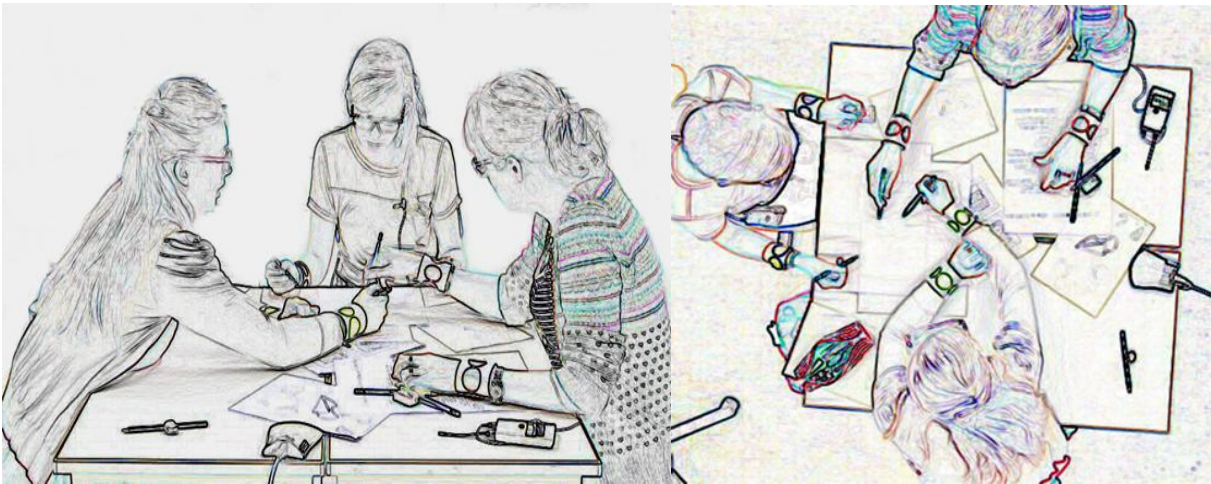


Figure 1: Stylized camera view from tripod camera (left) and from the ceiling (right).

A week after the last session, the teams were interviewed, and all four teams confirmed that all the discussions about the design assignment and design ideas were conducted during three, videotaped, design sessions. Therefore, it is safe to assume that we managed to capture each team's observable, collaborative design process completely on video. However, we cannot be totally sure if the team members communicated with each other about the design tasks outside of the video recorded sessions.

### **Method of data analysis**

In the video research, the data analysis is usually based on disciplined observation of the video recordings (Derry et al. 2010). In this study, we used the INTERACT video analysis program. For the macro level of analysis, the sessions were segmented into 2-minute intervals. The main content of the design activity was classified into theory-driven categories: (1) return to design brief (i.e., reading the given tasks), (2) analyse of design constraints (i.e., talk about given constraints in the assignment, define intended purposes or functions for 3D textile puzzle), (3) propose design idea (i.e., generate visual or technical design ideas), (4) evaluate, (5) organize (i.e., organize the team work, making plans for future steps), (6) silence and (7) off-topic talk. These theory-driven categories were adapted from design literature (Goel 1995; Welch, Barlex and Lim 2000) as well as our previous studies (Kangas, Seitamaa-Hakkarainen and Hakkarainen 2013; Lahti, Seitamaa-Hakkarainen and Hakkarainen 2004). During the analysis each segment was coded based on the main content of the segment (cf. Derry et al. 2010). The coding scheme was developed iteratively by the researchers together so that they shared a common understanding of the categories. After that each researcher individually coded her part of the data.

The macro level of analysis highlighted various aspects of the collaborative design process across all sessions and teams. To better understand the nature of the collaborative design process that the teams engaged in, we carried out K-means cluster analysis in order to identify teams that represented the same type of design orientation. The K-means clustering is an iterative portioning method of cluster analysis in which the data are divided into initial clusters and the centres of the clusters are calculated (Afifi and Clark 1996: 395). The variables used in the analysis were problem-centred activity (the proportion of categories 1+2), solution-centred activity (the proportion of categories 3+4) and process-centred activity (the proportion of categories 5+6+7). Through cluster analysis we identified highly similar cases not readily apparent by visual inspection. The first cluster emphasized problem-centred activity in the first and second session and process-centred activity in the third session whereas the second cluster was characterized by a higher portion of solution-centred activity in each session. For this reason, we named the first cluster a *problem-driven orientation* and the second one a *solution-driven orientation*.

Further, a content log of each segment was constructed (cf. Heath, Hindmarsh and Luff 2010: 62-63). Content logs are like field notes that provide a time-indexed outline of the events on the video (Derry et al. 2010). The content logs were sufficient to capture main activities and proposed design ideas during the sessions. Based on the content logs we identified when the kernel design ideas were found and how these ideas were transformed. We will provide a detailed description of the ideation in two design teams representing different types of orientation.

To examine the reliability of coding, two independent researchers carried out classification of 38% of the segmented data. The reliability for the first session was 92%, and the second session received an inter-coder agreement of 83%; these figures signify a highly significant reliability of the classification. However, inter-coder classification for the third session was first found problematic due to the different nature of the activities (quietness and short communications): participants were individually concentrating on the build-up of various pieces of the mock-up model. We negotiated about our classification in order to obtain better inter-coder agreement. After the second coding, the inter-coder agreement was better; showing inter-coder agreement of 88%. To conclude, the reliability of the classification was judged to be good.



## Results

### Overview of design activities

Since the whole design assignment was structured in three sessions: defining design constraints, visualisation, and building mock-up, all teams proceeded mainly following that order. However, there were some considerable differences between the teams. Table 2 highlights that the main activities in the sessions varied between teams.

Table 2: Proportions of the time (minutes) in the Design Teams' design activities during each session (silence and off-topic talk is combined).

	Return design brief		Analyse design constraints		Propose design ideas		Evaluate		Organize		Silence and off-topic talk		Total	
<b>Session 1</b>	<i>min</i>	%	<i>min</i>	%	<i>min</i>	%	<i>min</i>	%	<i>min</i>	%	<i>min</i>	%	<i>min</i>	%
Team Truck	21	40	32	<b>60</b>	0	0	0	0	0	0	0	0	53	100
Team Ball	2	6	10	28	22	<b>61</b>	2	6	0	0	0	0	36	100
Team Landscape	4	10	16	38	24	<b>53</b>	0	0	0	0	0	0	42	100
Team Robot	10	16	32	<b>50</b>	8	13	2	2	6	10	6	10	64	100
<b>Session 2</b>														
Team Truck	0	0	6	12	22	<b>46</b>	8	16	11	22	2	04	49	100
Team Ball	0	0	2	3	44	<b>65</b>	6	9	12	17	4	6	68	100
Team Landscape	2	4	2	4	32	<b>68</b>	8	17	3	7	0	0	47	100
Team Robot	2	3	18	23	30	<b>39</b>	10	13	14	18	4	5	78	100
<b>Session 3</b>														
Team Truck	0	0	2	2	10	14	28	30	29	<b>32</b>	20	22	89	100
Team Ball	0	0	4	5	22	27	30	<b>37</b>	10	10	16	20	81	100
Team Landscape	0	0	0	0	10	15	20	30	22	<b>33</b>	16	23	68	100
Team Robot	0	0	4	5	12	15	12	15	22	28	31	<b>37</b>	81	100

In the first session, all teams analysed design constraints by making a list of questions and a mind map as requested in the task instructions. The time used in the first session varied between 36 minutes to 64 minutes. Analysing design constraints was the main activity in Team Truck (60%) and Team Robot (50%) whereas proposing design ideas took the main part of Team Ball's and

Team Landscape's designing, i.e., more than half of the time used. According to the content logs, by the end of the first session the teams were in different stages: Team Truck did not have any design idea, Team Robot had some vague design ideas whereas Team Ball had two design ideas to be selected for further consideration, and Team Landscape had quite clearly made a decision about the theme of the 3D textile puzzle.

The time used in the second session varied from 47 minutes up to 78 minutes. Since the second session concentrated mainly on visualisation, proposing design ideas unsurprisingly played the main role in each team's design activities. The visualised ideas were mainly rough, outline drawings; also evaluating ideas as well as organizing team work increased compared to the first session. Unlike the others, Team Robot focused also on analysing design constraints (about 23%). As expected, all teams achieved a final solution for their 3D textile puzzles even though the design task caused some struggle, especially in Team Robot's design process.

The time used in the third session varied from 68 minutes to 89 minutes. On the whole, evaluation of design ideas and organization of the work increased further whereas proposing design ideas decreased. Team Ball used more time for ideation (27%) than any other team. The building-a-mock-up session also affected interaction between team members; there were more silence and off-topic talk during this session, varying from 20% to 37% of the time used in this session. Also a division of the work was typical, the teams made clear divisions of labour, i.e., one person was responsible for constructing certain pieces of the 3D puzzle. The mock-ups were simply made according to the drawings from the second session; they did not spark new alternatives; the received mock up materials were mainly used to implement a complete design object, however, some of the detail solutions became clear.

Cluster analysis revealed that Team Truck and Team Robot engaged in a problem-driven collaborative design process, and Team Ball and Team Landscape appeared to have a solution-driven design process. A summary of the orientations and outcomes in each team is presented in Table 3. In the following, we will provide more detailed accounts, respectively, of one of the problem-driven and one of the solution-driven design processes.

Table 3: Design Teams' orientations and outcomes.

	Team Truck	Team Ball	Team Landscape	Team Robot
<b>Orientation</b>	Problem driven	Solution driven	Solution driven	Problem driven
<b>Session 1: Defining design constraints</b>				
	Reduced mind map	Reduced mind map	Complete mind map	Complete mind map
<b>Outcome</b>	No formulated design idea or structural ideas	2 rivalling design ideas: a ball and a pyramid	1 committed design idea: a landscape	2 preliminary design ideas: doll, animal
<b>Session 2: Visualisation</b>				
<b>Received themes* and forms</b>	3 themes: animal, building, vehicle	2 themes: animal, building	3 themes: animal, plant, song/fairy-tale	1 theme: song/fairy-tale
	7 forms	8 forms	7 forms	7 forms
<b>Outcome</b>	Formulated design idea: Truck	Formulated design idea: Ball	Formulated design idea with details	Formulated design idea: Robot
	Line drawing with list of possible fastenings	Line drawing with structural and functional details	3 drawings with structural, functional and measurement details	Line drawing with structural and functional details
<b>Session 3: Building a mock-up</b>				
<b>Outcome</b>	Paper mock-up with one added feature	Wire mock-up, solutions for implementation	Clay mock-up with highly detailed surface, solutions for implementation	Wire and fibre fabric mock-up with finalized quality, one added feature

Note: \*As input to teamwork, each team member selected one random theme and three forms. In some cases, the same themes and forms were selected by different team members, resulting in fewer options for teamwork.

### Problem-driven collaborative designing

A characteristic of Team Robot's (Jane, Hannah and Shirley) design process was the problem-driven orientation. They started by reading the design brief and writing down questions related to the functional properties of 3D textile puzzle, such as "*Can a piece of the puzzle combine training for a number of skills?*" They considered many design constraints: borrowing of textile puzzles,

kids wanting to play more than once, child's age and skills that can be practised (e.g., classification skills, hand coordination, motor skills) while playing with a 3D textile puzzle. They decided to organize their working of the mind map so that each member was first individually writing down design constraints that she considered important. They were working silently about six minutes, and after that they negotiated and organized how they would proceed to make their common mind map.

As stated in the theoretical background, possible design solutions arise from a complex interaction between parallel refinement of the design challenge and the design ideas. Figure 2 presents a timeline chart of Team Robot's design process. It shows transitions between a 'problem space' and a 'solution space'.

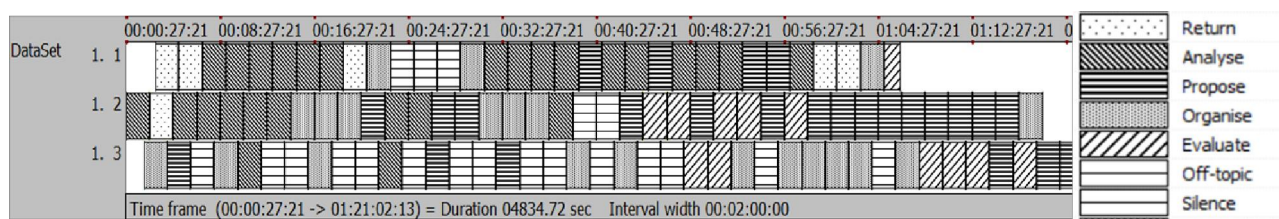


Figure 2: Timeline chart of Team Robot's design process.

In the first session, around 40 minutes (see Figure 2; top row), Hannah proposed a vague kernel design ideas about doll's body (torch) with detachable arms and legs by using different mechanisms such as zippers or Velcro. This idea was changed to an animal and later to a fairy-tale creature:

**Jane:** *It could perhaps be an animal with buttons and a snap fastener connecting the tail.*

**Hannah:** *It would contain the ability to take care of itself. We could use it for everyday skill training. For example, the buttoning is like this...*

**Jane:** *If you're thinking like that, then you could quite easily combine materials... If you're thinking that it's a cat in a bowtie, then there could be rustling inside it...*

**Hannah:** *and if we think about it – this is starting to sound more complicated... but if we think about a small blind child, then the sound and rustle sound would interest it.*

**Shirley:** *And normal children would be interested in the sound as well.*

**Jane:** *It could be a bell combined with the rustle sound in the inside... in principle.*  
(0:52:56-0:53:56)

Although Team Robot did not made any clear design decision of the 3D textile puzzle in the first session, they appeared to be fixated on the torch idea (i.e., doll, cat, fair-tale creature) and they had real difficulties in dropping that idea in the second session. During the second session (Figure 2;

second row) they negotiated a lot of the limitations of the task and wondered if they had possibilities to keep their original idea. In one point Jane pointed out that she is stuck with the animal idea because the received theme was a story “*we also have to keep in mind the story so that kids can recognize.*” Shirley also asked “*are we trying to catch the fairy-tale creature and should we decide about what creature it will be*” [known story or self-made story]?” It appeared to be painful to reach the direction where to start. In one moment Hannah supposed that “*if we look at these shapes we cannot get... for example a robot*”. But when Shirley disagreed and pointed out that it is actually possible, Hannah agreed with relief: “*actually over this robot idea you can easily create this construction story because thinking about a princess in pieces is not a nice story*”, and the idea of robot replaced the previous ideas:

**Jane:** *That's why I thought about an animal so it'd have a place over there (points to chest) and it's clearly a soft toy.*

**Shirley:** *I loved the robot idea.*

**Hannah:** *Well, we can begin making a draft design with these ideas in mind.*

**Shirley:** *Yeah we could... do you remember the robot song.*

**Hannah:** *Ruttunen* (starting to sing the robot song)

(0:35:19-0:36:16)

It was evident that the second design task caused some emotional confusion that led to delay in developing their vague idea. In any case, in end of the second session, they considered that they were able to solve design aims and constraints that they proposed in the first session (i.e., skills that can be practised while playing e.g., hand coordination and motor skills). Furthermore, solving the described hold-up they were also able to keep the idea of combining ‘body parts’.

In the third session, Team Robot worked with wire and fibre fabric. First up, they decided on a clear division of labour. After this, each student seemed to be free to decide on details for her part of the mock-up. Plenty of time was used for finishing the appearance of the mock-up in which case the model was rather the design object than the tool for planning the final product. During the session, the students worked both alone and together in order to create a shared design object. Ideation of details increased at the end of the session when the model was completed (see Figure 2; below row). During the last minutes of the session, they had ideas about magnetic details (see Figure 3) in the robot’s stomach and palms:

**Hannah:** ... that depends on what kind of hands will be, but we can think about that, do we put those hand – like these palms – pieces of Velcro so that we ...[shows the hands joined together]

**Jane:** And then sort of [hand gestures]

**Shirley:** Yeah, it could be fun.

**Hannah:** Then its hands can be arranged like this and then you could put something in the gap, if they're too long.

**Shirley:** Yeah.

**Hannah:** I once had an ape, which you could hang...

**Jane:** I had a teddy bear like that.

**Shirley:** Yeah, very interesting.

**Hannah:** Yeah then when the hands are hanging from the sides, then you can get it to lean forward...

-break-

**Shirley:** If it had magnets, which you could attach to something.

**Hannah:** Damn, that would be pretty neat.

**Jane:** Yeah it would.

**Hannah:** Then when we do this, we should maybe decide on the style, if it should be like a rag doll – with button eyes or should it be more industrial – which would fit the magnet idea much more.

**Jane:** hmm..

**Shirley:** We'll need to try – it depends on the fabric, will it take magnets.

**Hannah:** And how to use the magnets, if it's inside and is washed?

**Jane:** It could be sunk somewhere, so you need to place the hands in a certain position to activate the magnets.

**Hannah:** Here just place metal plates under [shows the stomach of the robot] and magnets at the end of the hands. (1:19:10-1:20:50)



Figure 3: Team Robot's mock-up and final product.

The previous excerpt of Team Robot's discussion highlights how a familiar solution of using Velcro was replaced with a more interesting magnetic solution. This decision refined their kernel idea. To conclude, Team Robot typically reconsidered their initial design ideas; in the second session, the idea that was considered impossible became possible, and during the third session, the new fastening solution finalized the idea of the 3D textile puzzle.

### **Solution-driven collaborative designing**

Team Landscape (Ann, Maj and Cindy) started by reading the design assignment and, soon after, they started to analyse design constraints by writing down questions. Maj proposed the first design idea of the 3D textile puzzle – a landscape that would consist of many pieces –after only 12 minutes:

**Maj:** *What came to my mind immediately was the kind of scenery... where there is this mountain and down the slope would be trees which would come to a lake and a cabin...*

**Ann:** *Could it be like... the kind of scenery that could be constructed in many different ways?*

**Maj:** *Yeah – like the mountain would be the heaviest element.*

**Ann:** *Yeah.*

**Maj:** *Somehow the cabin could be lighter.*

**Maj and Ann** at the same time: *Lake could be rustling.*

**Maj:** *Yeah – I just had this idea.*

**Cindy:** *Cool.*

**Maj:** *It could be something like... (0:12:07-0:13:07)*

They were apparently very keen on the landscape idea and while talking about design constraints and functions of the textile puzzle (Figure 4; Session 1, top row), they referred once in a while to this landscape design idea, and it was mutually accepted. They proposed many functional aspects for the textile puzzle such as the sense of touch and hearing, experiencing the three-dimensional form and playing together in pairs or groups but also alone. Toward end of the first session, they started to produce ideas for the landscape puzzle at a detailed level and proposed more detailed ideas about the pieces of the landscape consisting of mountain, lake, creek, bridge, house, tree and rocks. They also discussed the size of the whole textile puzzle and how the pieces could be

connected to each other. At the end of the session, they returned to the design brief and organized their work for a short time.

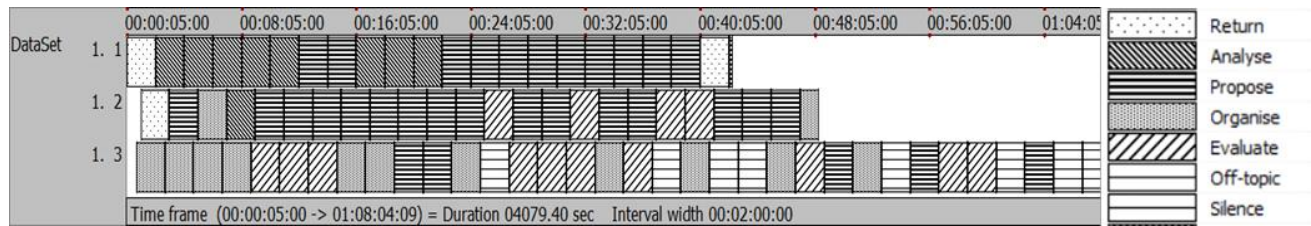


Figure 4: Timeline chart of Team Landscape's design process.

Team Landscape was happy about the received themes (animal, plant, story/song) and shapes since these were easy to adapt for the landscape pieces (e.g., triangle as mountain, rectangle as house). In the second session, ideation and sketching (see Figure 5) were concentrated on finding individual pieces and later solving the shape of the basic element. Solving the shape of the 'basic piece' formed the ground for the puzzle, so that places of these pieces could be moved and the pieces could be part of different kinds of landscapes. The following excerpt highlights how the solution of the basic piece was collaboratively solved:

**Maj:** *Do you get what I'm after – can you say it better, if the grass is just the shape – is it like this where you can get it combined like this [make figurative gestures about shape]?*

**Ann:** *Like this? [grabs pen and begins drawing]*

**Maj:** *Yeah, so that you can add it to one of these components.*

**Cindy:** *Then, what about the point of attachment – like this? [draws on paper]. If a child puts them randomly, then we need to consider the components relation to the point of attachment.*

**Maj:** *Which points of attachment do you mean?*

**Cindy:** *If we think of the stickers then we can put it either here or there [pointing]. So that they would fit in many different arrangements and so in that case the grass would be the basic element X.*

**Maj and Ann:** *Ah I see.*

**Maj:** *I was just thinking about the cabin, that if it's like this, does it have to be like this... Here we could use these kinds of shapes [corners off] and circles [draws on paper].*

(0:12:10-0:13:40)



Later on, they returned to develop the kernel idea again i.e., giving ideas about what would be the basic pieces, such as grass, lake, and hill. They reached the final shape of the basic pieces, and they continued to have ideas about each of the pieces:

**Maj:** *The basic building block is this [draws].*

**Ann:** [points at drawing] *It's one fourth of a circle so it works.*

**Cindy:** *Draw over there the other one [shows/points]. Is it the filling piece?*

**Ann:** *Or... the connecting piece?*

**Maj:** *Let's put here, here could be for example the grass, the lake [writes on top of the pieces] and the rocks can be their own conglomeration. (0:17:55-0:18:25)*

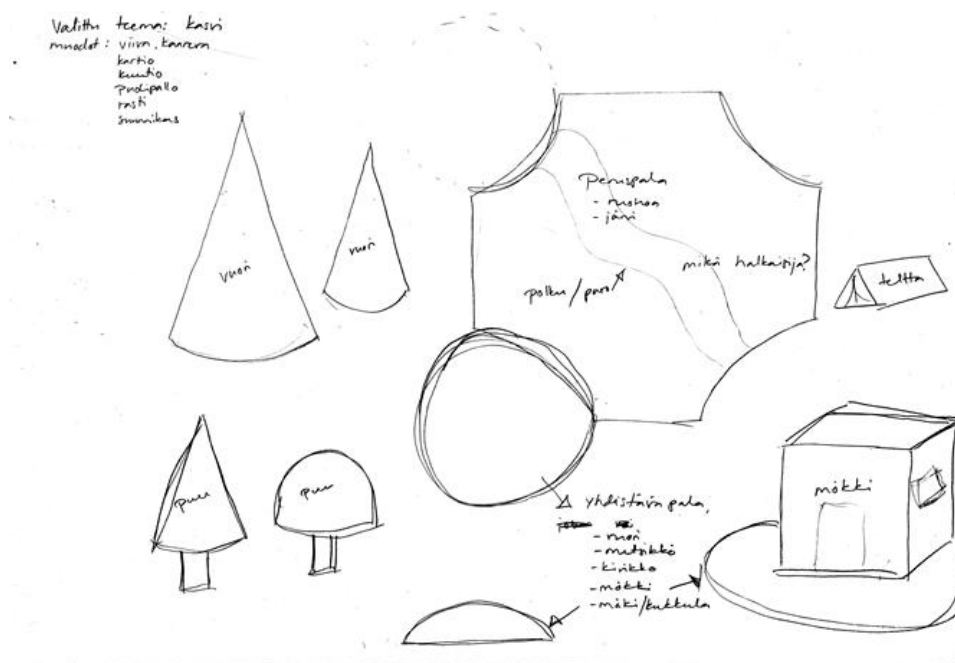


Figure 5: Team Landscape's drawing in the second session.

Team Landscape received modelling clay for their mock-up in the third session. Although the amount of clay constrained the size of the mock-up, building started quickly. Team Landscape worked expressively by moulding the clay into the desired shapes (Figure 6). During the moulding process, the students got images and ideas of the suitable materials for their textile puzzle. A large amount of sewing work became clear for students. However, they found solutions how to cut down the amount of work. In addition, they had to find a solution how the separate pieces would be connected naturally with each other:

**Maj:** ... Do you agree with me that, the lake's border would go like, if you think about how to actualize it as handicrafts then it'd be very difficult if it goes from there to the seam?

**Ann:** Somehow then...

**Maj:** Then you could connect it at the stream, we'd have to think at what point to connect it, yea if it comes from there and there, it can be connected like so...

**Cindy:** Should it come to like that edge?

**Maj:** It should...

**Ann:** Should it be so wide?

**Maj:** ... and then it should kind of hit two of these, and then you can connect it from here to one of these

**Ann:** Yeah, it has to hit that.

**Cindy:** Okay.

**Maj:** So look, here it can't hit, because there could be a mountain or something here.

**Ann:** So you cannot pass through here. (0:20:30-0:21:10)



Figure 6: Team Landscape's mock-up and final product.

In Team Landscape, the whole pattern of communication was focused and coherent, and the team members built on the initial design idea and on the each other's contributions. Through the sketching and building the mock-up, the design ideas, proposed solutions and decisions were made explicit and visible.

As stated before, the actual textile puzzles were produced later during the Sewing Technology course. While constructing the puzzles the students refined and reconsidered some of their design solutions, i.e. the design process continued throughout the sewing phase. However, this phase of the process was beyond the scope of the present article.

## **Discussion**

The purpose of the present study was to analyse the collaborative designing of university students being trained as textile teachers. The authentic design assignment underlined the importance and usefulness of service learning within the art, craft and design disciplines (cf. Kihm, Johnson and Napolitano 2010). The aim was to provide a design assignment that would simulate a real-world setting and support a collaborative approach to student learning. Furthermore, we wanted students to acquire experience of design process from the very beginning of their studies, to gain confidence in their own ideas and abilities to communicate about them. In the present study, all teams were able to work independently, and they organized available time very effectively.

The results indicated that all teams engaged in progressive design processes and were able create unique and practical design solutions. Progressive design processes were based on the movements between problem- and solution-spaces. Problem-driven design teams focused more on defining the problem and using information that was related to the design brief and constraints whereas solution-driven design teams focused more on generating solutions. Although it was possible to identify these two orientations, we had no means to rank them but only to highlight qualitative differences between them. According to Cross (2004), expert designers typically utilize a solution-driven approach to design problems; however, this approach is developed thorough deliberate practices by solving, incrementally more complex design problems over a set period of time. In the present case teams could utilize either problem-oriented or solution-oriented design processes to achieve successful results.

All teams accomplished a final solution for their 3D textile puzzles even though the visualisation task in the second session caused some confusion for teams' processes. At some point, all teams referred to and negotiated about the limitations of the visualisation thorough (i.e., received themes and forms), and there were some difficulties because they were not allowed to continue as they wished. In responding to these kinds of unexpected changes a team must overcome a variety of obstacles (McComb, Cagan and Kotovsky 2015). One obstacle is design fixation, considered as premature devotion to a design idea. Actually both teams (Team Robot and Team Landscape) fixated on their first ideas already during the first session, however, they used different ways to

respond to the new problem. Team Landscape simply became acquainted with the new problem representation and recognized that they could easily adapt their solution to new requirements. This was done on the fly, without paying too much consideration to the problem. In contrast, team Robot used more time to understand the new requirements, but eventually they were able to solve the problem that corresponded to their original idea about detachable body parts.

In design education, students are developing knowledge and skills to model, design and construct ideas into physical artefacts. In this case, the third design session was organized around constructing material representations of the 3D puzzles, and each team had restricted material to use. It was expected that building a mock-up would push teams to revisit their previous design ideas, however, the mock-ups did not trigger many new design ideas; the materials were used to implement already completed design ideas, though these became more detailed.

Many learning scientist have been inspired by both the studio model as well as problem-based learning (Sawyer 2012). Lee (2009) proposed that design academics should implement the language of problem-based approaches, in order to take part in broader educational discussions. According to Sawyer (2012), studio model learning is characterised by authentic real word problems (in the form of a design brief), guided problem solving (i.e., specific set of constraints or sub-tasks that confine how students can proceed), importance of externalization and reflection as well as careful planning of course schedule and curriculum design. Furthermore, educators guide students by balancing their learning of domain specific skills and creative abilities. In present study the design task was authentic and guided by the set of design constraints. The student teams were autonomous regarding how to proceed within the time limits, yet structured design activities (sub-tasks) emphasized externalization, reflection and interaction between team members. In collaborative design projects, students faced challenges as part of their learning: in particular, they needed to design while they were just learning about designing, and needed to utilize design tools and representations that they were just learning; they also had to deal with issues of designing their process simultaneously with designing products. However, despite the complexity and the challenges, it would be worth the effort if the students learn to implement the studio model with characteristics of problem-based learning in their future projects as textile teachers.

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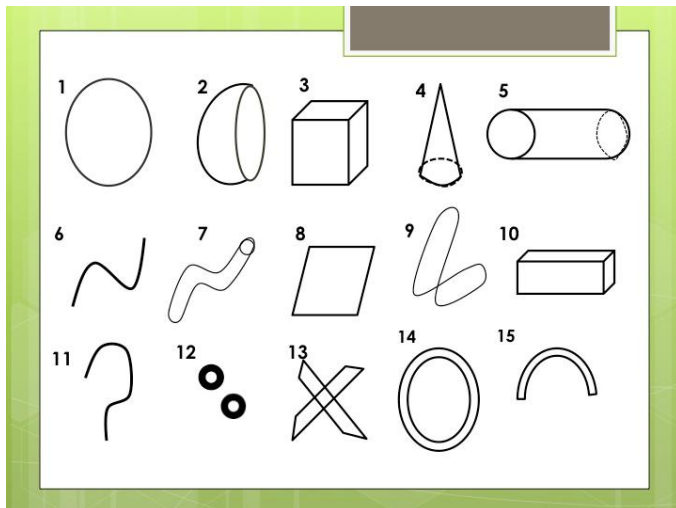
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## Appendix: Visualisation tasks

### 1. Phase: Creative problem solving task, individual work.

1. Pick three random numbers from 1 to 15 and write them down.
2. Pick one number from 1 to 8, and write it down.
3. Create an interesting, potentially useful object by combining the forms (see picture below) corresponding the numbers you picked in (1). You may combine the forms as you like, and resize them. You may not change the forms, other than forms 6 and 7, which you may bend or stretch.



4. Check which theme in the following list corresponds to the number you picked in (2), and modify your object to agree with your theme.

Themes:

1. Piece of furniture
2. Bridge
3. Plant
4. Song/fairy-tale
5. Building
6. Vehicle
7. Animal
8. Tool

### 2. Phase: Visualisation, teamwork.

1. Share your work from previous phase and discuss your solutions.
2. Select a theme and forms you want to use in your team's 3D textile puzzle. You may use all the forms you picked in previous phase, and you may combine them as you like.
3. Sketch a 3D textile puzzle using the forms from (2).